

GEOLOGY/GEOMORPHOLOGY

PHYSIOGRAPHIC REGION

In Missouri, the basin is equally divided (north and south) by the high-relief Ozark Plateau (to the north) and the low-relief Mississippi Alluvial Plain (to the south) (Figure nd). Wappapello Dam is located on the boundary of these natural divisions. Subdivisions of the Ozark Plateau include the St. Francois Mountains and the dissected Salem Plateau regions. Features in the Mississippi Alluvial Plain include low alluvial terraces and ridges which separate the flat plain into distinct subbasins that facilitates artificial drainage (Missouri Department of Natural Resources (MDNR) 1986a). Land elevations range from 1,740 ft National Geodetic Vertical Datum of 1929 (NGVD) in the headwaters to 234 ft NGVD at the Missouri/Arkansas border.

Radical differences in the geology of the upper and lower portions of the basin, and the influence of Wappapello Dam are responsible for the basin's divergent north-south distinctions related to hydrology, habitats, biota, land use, and water quality (Figure ge). Therefore, for the purpose of this report, the St. Francis Basin is separated into its two dissimilar subbasins: the upper subbasin above Wappapello Dam and the lower subbasin below Wappapello Dam.

GEOLOGY (UPPER SUBBASIN)

The headwater area is dominated by the Ozark uplift (St. Francois Mountains) which has exposed outcrops of Precambrian igneous rock (granite, rhyolite, felsite) on as much as 50 percent of the surface on some slopes (MDNR 1986a). The hard igneous rock has no overburden, and shut-ins, cascades, and waterfalls produce ancient rigid boundaries that control the course, gradient, and floodplain features of the first 80 miles of the river channel. Downstream, igneous rock is replaced by hard Cambrian dolomites and sandstone. Eventually, cherty Ordovician dolomite becomes the primary underlayment adjacent to the Wappapello Lake basin.

The absence of a deep cherty residuum in the igneous Ozark uplift and the formation of erosion resistant upland soils results in little gravel accumulation in the alluvial floodplain soils. Channel substrates contain a significant proportion of stable cobble, stone, and boulders, and streambank soils are more cohesive than in most Ozark streams because of lower densities of gravel. The Big Creek watershed is not strongly influenced by the St. Francois Mountains uplift. It is similar to the adjacent Black River basin, with its deep, cherty limestone residuum. The result is an abundance of gravel in Big Creek.

GEOLOGY (LOWER SUBBASIN)

The alluvial plain (Mississippi Embayment) downstream from the Wappapello Dam is topped with a 150-ft Quaternary layer of unconsolidated gravel, sand, silt, and clay (MDNR 1986a). Crowleys Ridge and other hills are underlain by Cretaceous and Tertiary rocks and covered with loess. The hills and natural terraces separate the alluvial plain into distinct basins.

SOIL TYPES (UPPER SUBBASIN)

Soils are transitional from the dominant Ozark Dome region above Wappapello Lake to the Ozark Border region adjacent to the lake (MDNR 1986a). Soils formed in the hard, igneous rock of the upland ridge tops lack an overburden of chert or loess and are typically described as extremely bouldery, cobbly, or stony with outcrops sometimes occupying 50 percent of the surface area (Natural Resource Conservation Service (NRCS) 1981, 1991, 1995a and 1995b). Fertility is low, reactions are acidic, runoff is rapid, and water capacity is low, which produces extremely droughty conditions most suitable for woodland and limited grass production. Soil series most frequently associated with the uplands are Irondale, Syenite, Delassus, and Clarksville.

The finer silt-loam soils formed on the slopes also contain a large proportion of stones and boulders, and a chert overburden appears on some foot slopes. A fragipan is usually present which can restrict root depth to less than three feet. Soil fertility is low, reactions are acidic, runoff is rapid, but water capacity is high and droughty conditions are limited to hot, dry summer periods. Some of the soils on the slopes can be tilled, but erosion hazards and low crop yields tend to limit agriculture activities to hay and pasture production. Soil series most frequently associated with the slopes are Auxvasse, Killarney, Courtois, Fourche, and Wilber.

The sand-silt-clay loams formed in floodplains are highly fertile, but fertility tends to decrease to moderate in a downstream direction. Soils range from neutral to only slightly acidic, runoff is moderate, and water capacity is high. Most of the floodplain soils can be tilled without a serious erosion threat, but hay and pasture products can often produce better yields than row crops. Soil series most frequently associated with the floodplains are Wakeland, Haymond, and Pope.

SOIL TYPES (LOWER SUBBASIN)

The soils in the lower subbasin are formed from deep alluvial deposits in the Mississippi Embayment region (MDNR 1986a). All of the silt-loam soils in the narrow subbasin (constricted by levees) share common characteristics of high fertility, strong acidity, poor drainage, moderate permeability, slow runoff, and high water capacity (NRCS 1979 and 1985). Outstanding row crop production can be obtained in the wet soils if the water table is lowered through artificial drainage (ditches) and lime is applied to neutralize the surface acidity. The soils also provide excellent growth potential for trees. The dominant soil series throughout the subbasin is Falaya. Some drier Dubbs silt-loam is present immediately below Wappapello Dam and an extremely wet Sharkey silty-clay is widespread near the Arkansas border.

WATERSHED AREA

The basin drains 1,839 square miles in Missouri (United States Department of Agriculture (USDA) 1981). This does not include the Little River by-pass system which enters the lower St. Francis River in Arkansas. About 71 percent of the drainage area (1,315 mi²) is in the upper subbasin and 29 percent (524 mi²) is in the lower subbasin (Table 1). Drainage in the upper

subbasin is natural and is comprised of numerous small watersheds. Most of the drainage in the lower subbasin, however, is controlled by a system of levees and drainage ditches that restrict the entry of tributaries into the partially channelized mainstem. Most of the west bank is a major levee which forces runoff westward into the Black River basin. Consequently, the west bank has only a few tributaries, just below Wappapello Dam, and the east bank contains only a few controlled inlets.

STREAM MILEAGE, PERMANENCY, AND ORDER

The St. Francis River, from its headwaters to the Arkansas/Missouri border, is 225 miles long. A total of 4,032 tributary reaches occupying 4,102 miles of channel, in both subbasins, were identified, ordered, measured (by hand dividers) and classified as either intermittent or permanent as indicated on United States Geological Survey (USGS) 7.5 minute topographic maps. The names, mileage, and permanency of all 151 third order and larger streams were tabulated for each subbasin by order, watershed, and hierarchical river mile position in each watershed and is on file at the Missouri Department of Conservation's Southeast Regional Headquarters.

The upper subbasin is drier than most Ozark drainages on the Salem Plateau because of poor groundwater recharge associated with the predominance of impervious rock. Stream permanency is more typical of the prairie streams in north and west Missouri where 10 to 20 square miles of watershed are needed to maintain each mile of permanent stream (MDNR 1986a). Local exceptions to the ratio of basin area to length of permanent stream are the mainstems of Big Creek and the Little St. Francis River where the watersheds only need about three to four square miles to maintain each mile of flowing water.

The apparently liberal USGS topographic map designation of 688 miles of permanent streams does not agree well with the 281 miles of stream above Wappapello Dam that are classified as permanent under the Missouri Water Quality Standards Code of State Regulations (MDNR 1981). The Code of State Regulations permanent mileage estimate is probably a more accurate assessment because it is based on a thorough survey of field observations (Funk 1968). Most of the disagreement between the topographic map measurements and the Code of State Regulations mileage estimate probably occurs in the second and third order channels of the upper subbasin where the aquifer is known to be poor and base flows are unstable. A similar disagreement between permanent mileage estimates was noted in the adjacent Headwaters Diversion basin (Missouri Department of Conservation (MDC) 1994).

Flow in the mainstem of the lower St. Francis River is primarily regulated by water released by Wappapello Dam. However, the permanency of tributary streams in the lower subbasin is similar to the wet Ozark region where only four to eight miles of watershed are needed to maintain each mile of permanent stream. A high water table and large amounts of surface water compensate for the low relief that is usually associated with high watershed to length of permanent stream ratios (MDNR 1986a).

The USGS topographic map designation of 234 miles of permanent stream in the lower subbasin agrees well with the 204 miles of permanent stream classified by the Code of State Regulations (MDNR 1981). The closer agreement in the lower subbasin is probably due to the lower percentage of second and third order channels designated as permanent on topographic maps.

CHANNEL GRADIENT

Gradient information was calculated from USGS 7.5 minute topographic maps (20-ft contours in the upper subbasin and 5- or 10-ft contours in the lower subbasin) and tabulated by subbasin, watershed, stream, and order (Table 2). Gradient plots were prepared for the mainstem and 38 fourth order and larger tributaries. All gradient information is on file at the MDC's Southeast Regional Headquarters.

The St. Francis River flows swiftly out of the steep uplift of the St. Francois Mountains and meanders through the moderately-sloped Salem Plateau before spilling out onto the flat Mississippi Alluvial Plain after exiting Wappapello Dam. The steep gradients in the upper subbasin are influenced by the uplift which has exposed massive outcrops of erosion-resistant granites that provide hard points, vertical controls, and rigid channel boundaries. The result is an undulating mainstem gradient that provides much habitat diversity. This includes some spectacular and often dangerous whitewater rapids that are rated Class III, IV, and V, depending on river stage (Hawksley 1989). The west side of the subbasin is much steeper than the east side. West side tributaries such as Big Creek and Stouts Creek are two to four times steeper, run straighter courses, and contain harder substrates than typical east side tributaries such as Wolf Creek and the Little St. Francis River (Table 2).

On the alluvial lowlands of the lower subbasin, the partially channelized mainstem gradient drops at a fairly consistent rate of one ft/mile for 100 miles through the Bootheel region of Missouri. Prior to channelization and levee construction, which greatly reduced the length of the channel, the gradient was considerably less than 0.5 ft/mile. Tributary streams that drain low alluvial terraces are typically low gradient, engineered channels, such as Mingo Ditch (Table 2). Some headwaters fall steeply off the west slope of Crowley's Ridge.

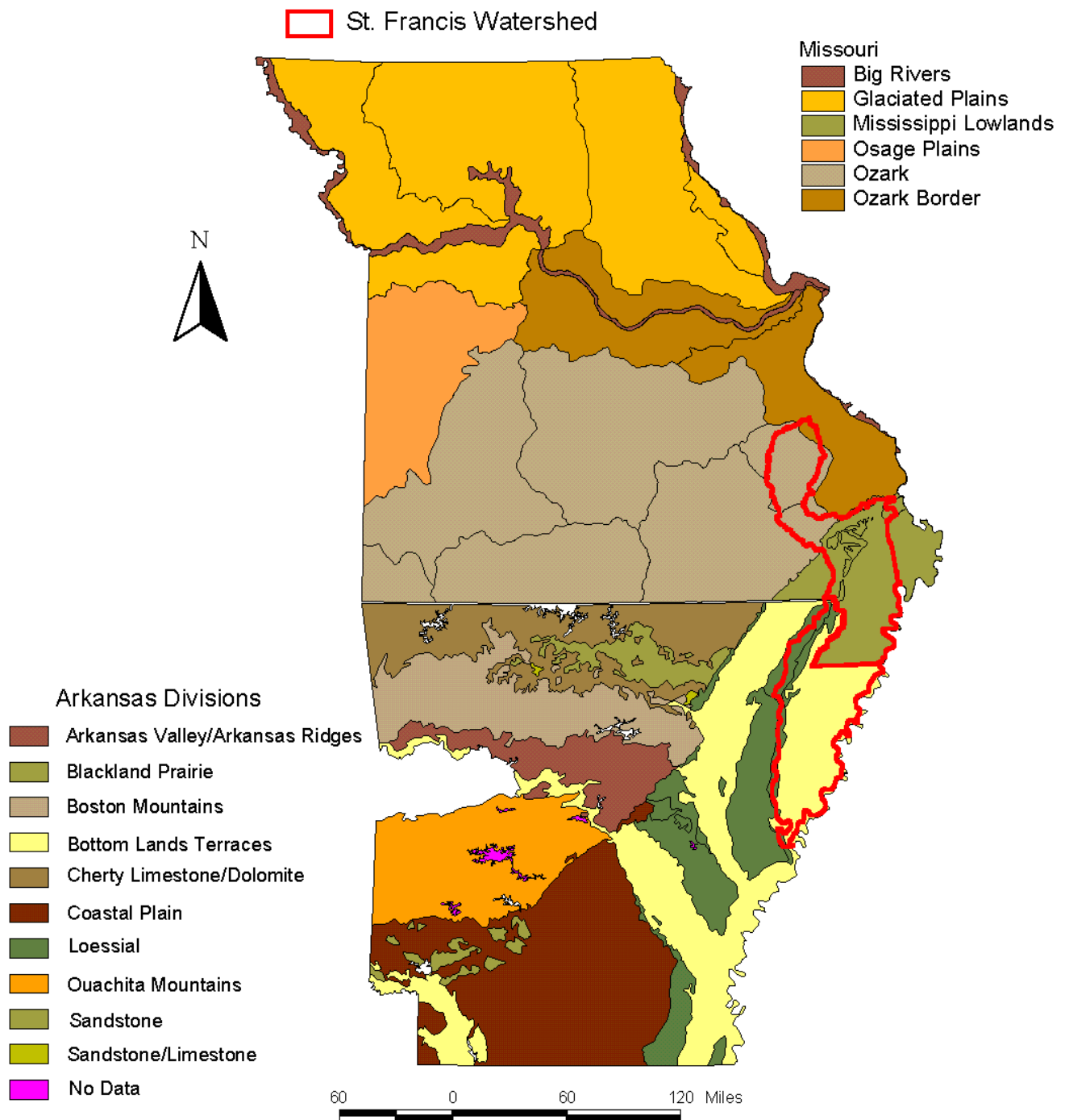


Figure nd. Natural divisions in the St. Francis watershed, in Missouri and Arkansas

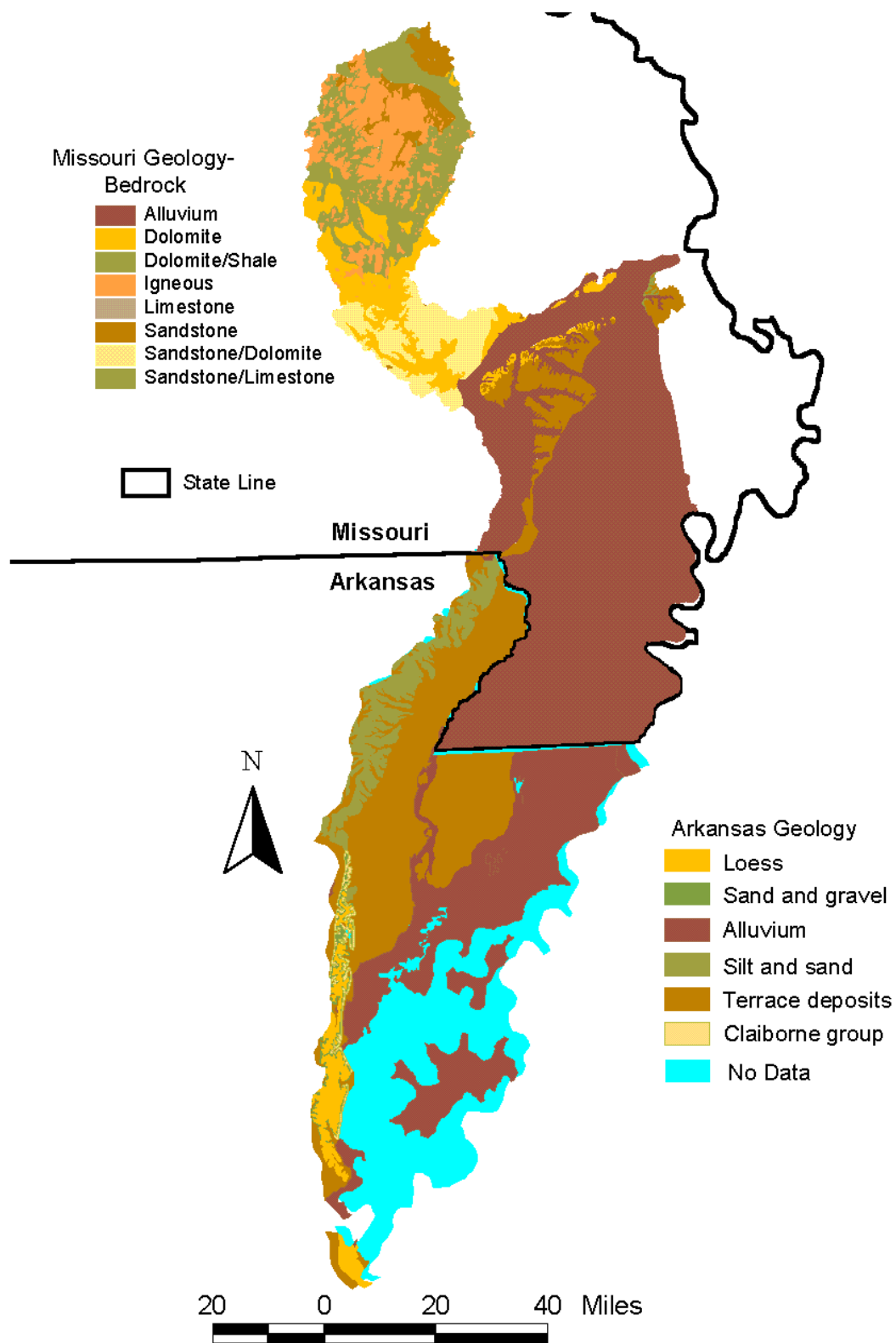


Figure ge. Geological divisions in the St. Francis Watershed in Missouri and Arkansas

Table 1. Drainage area of major watersheds in the St. Francis River basin, Missouri (modified from: USDA 1981)

Watershed	Max. Order	Area (mi²)	% of Subbasin
Indian Creek	4	25.5	1.9
Wolf Creek	5	65.9	5.0
Doe Run Creek	4	30.8	2.3
Wachita Creek	4	31.0	2.4
Stouts Creek	5	77.8	5.9
Little St. Francis River	5	139.2	10.6
Cedar Bottom Creek	4	16.9	1.3
Marble Creek	4	49.5	3.8
Twelvemile Creek	4	64.0	4.9
Cedar Creek	4	23.8	1.8
Big Creek	5	197.0	15.0
Clark Creek	4	54.6	4.1
Hubble Creek	4	19.0	1.5
Big Lake Creek	4	30.6	2.3
Otter Creek	4	74.2	5.6
Lost Creek	4	68.1	5.2
Asher Creek	4	23.7	1.8
Wappapello Lake	6	13.9	1.1
All Smaller Tributaries	≤3	309.6	23.5
Upper Subbasin Totals		1315.1	100.0
Mingo Ditch	5	140.9	26.9
Dudley Main Ditch	5	155.8	29.7
Un-named Ditch	5	49.0	9.3
Varney River Ditch	4	44.0	8.4
All Smaller Tributaries	≤3	134.5	25.7
Lower Subbasin Totals		524.2	100.0
St. Francis Basin Totals		1839.3	

Table 2. Channel gradients of primary streams in the St. Francis River basin.

Stream	Average Gradient (ft/mi)					
	6°	5°	4°	3°	2°	1°
Upper St. Francis River	4.7	8.0	18.1	11.6	43.0	225.0
Big Creek		11.2	29.4	45.4	75.4	160.2
Stouts Creek		21.5	28.8	53.6	70.1	166.7
Little St. Francis River		7.6	8.9	35.1	62.1	133.1
Wolf Creek		4.1	5.0	14.7	23.1	55.6
Lower St. Francis River	1.1	---	---	---	---	---
Mingo Ditch		1.3	4.5	32.1	51.4	84.0
Lick Creek/Dudley Main Ditch		2.6	6.2	8.1	22.2	66.7
Un-Named Ditch		2.7	3.4	16.6	58.8	212.5